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WHAT IF THINGS GET WORSE?

Really Grand Challenges for Modeling and Simulation in a Risky and Complex World

Or

Modeling and Simulation for the “Greater Good”?

Act 1: Setting the stage

Today Modeling and Simulation-- ---as an important practice or industry or area of expertise ----- is at a complex crossroad – a sort of cyber-highway--where these complexities meet—technical, economic, environmental, geopolitical and cultural. They may converge or collide. Let’s not kid ourselves. It is all too much for any one person or organization. Malcolm Gladwell said it. “We have constructed a world in which the potential for high tech catastrophe is embedded in the fabric of everyday life.”

We are surrounded by problems that scream at us from our television, Internet and social networks along with billboards and protest signs. We face not just high tech catastrophes but, also, landslides, earthquakes, tornados, floods and hurricanes and large-scale criminality. Evil, war, famine and pestilence have not gone away. It is all too much to think about.

My friend, George Peabody, who taught me everything I know about power said that addressing such issues requires that we constantly build our network, information resources and the credibility and visibility of our work. That is how we will build the power of simulation so it can change the world --even maybe, save it.

We need all the help we can get and give one another because our human early warning systems appear to be out of kilter.

We seem to have trouble imagining how small failings can continue to lead to catastrophic disaster. Think about O-rings and blowout preventers. One is reminded of the old nursery rhyme, "For want of a nail, a shoe was lost/ for want of a shoe the horse was lost/ for want of a rider the battle was lost and so the kingdom fell."

Although the investigation will take more time for real answers, it is worrisome that a rig worker reported to the BBC that-- weeks before the explosion of Deep Ocean Horizon. -- he identified a leak in the oil rig's safety equipment --the Control Pod of the blowout preventer which has giant shears designed to cut and seal off the well's main pipe. With both electronics and hydraulics, these are effectively the brains of the blowout preventer. No one fixed it, he alleges, they just shut it down and relied on the other control pod --an act deemed unacceptable by petroleum expert, Tad Patzek, at the University of Texas. The US Congress has identified numerous other problems with the blowout preventer, including design problems and unexpected modifications. Just looks like lots of lost opportunities for M&S. It also raises issues about technology research advances we need such as modeling non-solid objects: water currents, wind, and fire.

When I say the words "Disaster" and "Florida". How many of you think "hurricane"

Let me tell you about 1992 and Hurricane Andrew. In those days, I was KSC Technology Reinvestment Manager working in advanced projects and technology transfer. I was making movies on commercial development of Space. Although I live in Cocoa Beach Florida, I was in Rockport Maine at a workshop for producing documentaries using archival film. During a break, I called home on a Sunday morning to hear from my

husband that he had just thrown our outdoor chairs-PVC pipe-- in our pool and was working with the neighbors to secure the sailboats on our canal. I did not even know a storm was brewing. He said a NOAA track had it heading-- that afternoon --straight for our town (about 15 miles south of the Kennedy Space Center on the last barrier island ten miles off the mainland).

I went back to class to tell them what was happening in Florida and the immediate reaction from everyone was --disbelief. Disbelief is the usual—expected-- first reaction to something unexpected. This is especially true when it is bad news. People said, “You are kidding—there cannot be a hurricane.”

“I do not believe it-- That cannot be a plane that is hitting the other Tower.”

It had been 30 years since Florida had experienced so damaging a hurricane. Population expansion meant half the people in the State had never been through one. Few people were well prepared.

After my class I drove to Camden, the nearest town, to buy a newspaper so I could learn more, but only found the Portland paper that had no news north, south or west of Maine. I drove in the opposite direction to Rockland where I found a Boston paper but, there, too, news stopped at the southern border of Massachusetts. Neither paper made any mention of the hurricane that was consuming everyone's interest at home proving, it seems, that all disasters are local.

Atlantic hurricanes begin as tropical waves off the west coast of Africa that can quickly become strong tropical storms. This storm dissipated a number of times but each time it rebounded in favorable conditions (favorable to a hurricane not for humans or other creatures). It grew stronger. North of Puerto Rico, the storm turned westward where it

made landfall twice in the Bahamas. As it continued to move westward crossing the Gulf Stream it picked up more power and definition. Andrew became a Category 5 hurricane. That used to be called a Great Hurricane and it still is a great hurricane. I stayed in Maine and missed all the fun

Andrew made landfall on August 24 more than 220 miles south of Cocoa Beach ---so much for accurate models.

With wind speed of 165 mph, and pressure measuring a very low 922 mbar. Andrew left 150-200,000 people homeless, 1.4 million without electricity or drinking water and badly damaged offshore oil services. It killed 26 people. Damages of almost \$41 billion, make hurricane Andrew second only to Hurricane Katrina whose damages totaled \$90 billion.

Hurricane Andrew also caused immense ecological damage -- uprooting Mangrove trees on about 70,000 acres of land in the Biscayne and Everglades National Parks, destroying almost one third of the coral reefs in the Biscayne National Park and 90% of the native pinelands in Dade County where Miami is. Destruction spread beyond Florida-- over 80% of the oyster reefs off the Louisiana coast were lost and 40 miles of sand were stripped off its barrier islands leaving the old coastal marsh vulnerable to more damage. The hurricane threatened marine life forms with dangerously lowered oxygen content in the Gulf of Mexico. The storm killed almost 182 million fishes. It caused some damage in the Southern Appalachians and dissipated finally in the Middle Atlantic States

What happened after Hurricane Andrew in 1992 was the development of almost the entire emergency management programs in the US as a systematic pattern to reduce, respond and recover from disaster.

Andrew did, for many years, make us all more aware of hurricanes—their power and impact.

In 2004, too, the hurricane season was notable—it was deadly, costly and unbelievably exhausting. Between August 4 and September 15, 43 days, five named storms made landfall in Florida, four hurricanes, three of them with at least 115 mph sustained winds: Tropical storm Bonnie, hurricanes Charley, Frances, Ivan and Jeanne. We experienced over 3000 deaths and roughly \$50 billion in damage. Mandatory evacuation seemed the norm. The first time we were evacuated, my husband said, “Look around. When we come back there may be nothing but a concrete slab.”

That summer, whenever we had electricity, we watched television weather reports constantly. The screen covering our pool was blown down. We lost a fig tree and a few tiles on our boathouse roof (actually caused by a neighbor boat). We used a battery-operated radio a lot, kept cash on hand, were grateful for sea breezes when we had no electricity so no air-conditioning, made coffee on a charcoal grill, repeatedly boarded up the sliding glass doors with plywood held in place by large garbage pails filled with water, made a “safe room” in a hallway, ate oddly and were big fans of the meteorologist who got the path of Charley right. He was the only one.

We became amateur weather forecasters ourselves so that, finally, facing a storm bigger than the State of Florida, hurricane fatigued and not sure where to go anyway—we maintained a low profile and stayed in our house for the third mandatory evacuation. Our prediction of the path was right and we were merely inconvenienced. We have never filed an insurance claim but our policy has quintupled and, even, the process of buying insurance is insane.

We'll have to watch what happens next.

It is also a story of how quickly we forget. That was 6 years ago. Memories are fading and there are many fewer announcements about hurricane preparation this summer.

The great philosopher William James said he of himself, that he had "an attention span of 10 seconds" So the rest of us need not feel so bad. I do wonder how he measured it. I think about how just observing subatomic particles changes them and have a hard time imagining how he both thought of something and measured how long he thought about it.

Ah well. Someone on the Internet claimed that *USA Today* said our attention span is 23 minutes. I cannot find the source, and I incline to favor William James. We all, as Ellen De Genres said, seem to suffer from the TBD syndrome-- Too Busy Disorder. It all seems too much. John McLeod famously reminded us that simulation is a hopeful thing when the real thing is too much.

Rick Severinghaus, in a 2006 SISO paper on modeling and simulation related to disastrous events, proposed important roles for modeling and simulation. He described a volcano on the Canary Islands with potential for very bad multinational, multicontinent effects. Cambe Vieja volcano has erupted often, including 1949 and 1972 when its western part slid partially into the Atlantic before stopping and resting precariously on the edge of the sea. Future eruptions could make that whole giant western flank of the island fall into the Atlantic creating a tsunami devastating much of the Atlantic rim- a bulge of water the model says would be 90 meters high with waves of 100 meters. That, for the rest of us, is 238 feet. An hour later, 50-100 meter waves would devastate western North Africa. Spain and the UK would soon see 7-10 meter high waves. But, after 8 hours, the Florida coastline would be hit by more than 20 meter high waves—a surge of

more than 60 feet-- where our house, two blocks from the Atlantic Ocean sits at 6 feet above sea level.

In the past century, we built near the oceans, on mountains, on rivers, on flood plains—because we can. This is not just an American phenomenon. Floods in Turkey in 2009 were attributed in large part to construction that involved deforestation and consequent erosion. Elsewhere, too.

We saw a lot of strange environmental events this past year—some creating crises in their wake. We anticipate more of them. The news proves more and more odd with stories of snow in Genoa, floods in Saudi Arabia, glaciers melting in Bolivia, the Maldives sinking and salt rising along the Nile. We hear about potential asteroid crashes. On nightly television, we see too many victims of floods, hurricanes, cyclones and typhoons, fire, tornado, tsunami, bombings, landslides and cross-boundary criminality.

Some disasters -- tornado, explosion or earthquake--provide no warning. A hurricane can seem to take forever to make up its mind. Some start small—a fire, a cyber-attack, landslide, flood or an oil spill-- and grow larger and larger.

Recently we learned that flawed economic models were at the base of much of our financial recession. That is both a worry and opportunity for us. We know that models lie. They are a simplification, a selected abstraction, of reality. Nonetheless, all of us, everywhere base decisions on models—computational, visual, tactile and written. We always hope that we do not leave anything out that impact the desired outcome especially when we deal with absolutely consequential consequences. John Sterman, a Massachusetts Institute of Technology (MIT) computer scientist reminds us “we cannot validate any model in terms of truthfulness.” Just something else to be vigilant about.

In Florida, since April 21, as elsewhere, our news has focused on “The Crisis in the Gulf.” Terra Earth and Disaster Management Digest reported. on June 21, another oil spill—unreported by any authority—this time on the Red Sea that threatened marine life and tourism, and that, on the same day—a final report on an oil spill in August 2009 was submitted to the Australian government but not released due to pending litigation. The Chinese and Taiwanese, also, on the same day announced plans to address potential oil spill responsibilities. Other news: Illegal toxic waste disposal off the Ivory Coast resulted in criminal charges in Holland against a Swiss company, a controlled flood in California meant to relieve a dam produced an unexpected canyon over a mile long in 3 days stripping the valley of all vegetation. Bhopal India still experiences —since 1984-- inadequate clean up and a too slow pace of justice. Arsenic in the water killed thousands in Bangladesh The news on one ordinary day alone, reported over 300 people killed in floods, volcano eruptions, storms and coal mine explosions. How many more went unreported?

In another deep water drilling enterprise—much deeper and in a more hostile environment -- the word is "We would never allow such a thing as Deep Water Horizon to happen. Our policy, procedures, training, equipment are such that it will not happen." Somehow that does not seem like a good enough answer. But it is familiar.

ACT 2—Confrontation

When it comes to measuring and responding effectively to risk, humans prove to be... not so great. This is especially true in situations that are too complicated or complex for us to readily understand. The problems are too big. We have too many of them.

The Red Cross says that disasters impact 250 million people each year. That means that 700,000 people are having a very bad day-- today.

Lately, we have been like deer caught in the headlights.

Gale Collins in the New York Times echoed the feelings of a lot of people when she noted that the plan for handling a deep-water spill is not to have a deep-water spill.

Again and again when someone asks, "But what if something goes wrong? What if something gets worse?"-- the answer we hear is, "I don't do hypothetical's". Twenty-first century superstition -- like some sort of remnant of the Middle Ages --seems to manifest itself into the belief that having Plan B, much less a Plan C for Contingency might be construed as lack of faith in Plan A.

The Deep Water Horizon story cites many small failures that were over-looked. It is just human nature. A lot of time nothing does go wrong. But we all know it is like playing Russian roulette. Success in the last round is not a good predictor of success this time.

Nonetheless, as things seem to go well, people adjust their definition of acceptable risk.

We balance likelihood, risk and potential consequences. Unlikelihood, however, can no longer be taken lightly.

We are sitting here comfortably in Ottawa and can easily forget near misses.

In Turkey, earthquakes, landslides and flood create 80% of the costly disasters that impact the country each year-- socially, economically and politically. Following the devastating earthquake of 1999, Turkey enhanced its approach working with the Red Cross and the United States Federal Emergency Management Agency (FEMA), now part of the Department of Homeland Security. They improved communication capability and with FEMA, supported a substantial train -the -trainers program that has, following

analogue exercises and online capability, grown and developed to become a respected university degree program through TUBiTAKE, Turkish Scientific and Technical Institutes Universities. The first 13 graduates found immediate employment in industry and government. The experience has demonstrated, not surprisingly, that university level courses encourage systematic introduction to and treatment of risk prevention in complex situations and systems. Related research findings directly aid practice.

It has taken several decades for the world to see both the computer-based simulation and emergency management industries, as something to be taken seriously, to be seen as professions built on ideas worth studying. The actual management of risk reduction, however, can be seen as mere common sense, "seat of the pants" work.

Unfortunately, in a disaster, common sense is often absent. Instead of Hemingway's famous "grace under pressure", we experience all those deer in the headlights. Too often communication instead of being open and reliable is restricted and suspect. Cover-up becomes a cowardly norm. Crisis teams may organize themselves too late while the damage spreads. All too often plans and policies go untested while too few people really know how to reduce, respond and recover from the disaster.

Only 8 universities in the US provide education similar to the program in Turkey and too few exist around the world, even fewer are active in advanced research. Few exist in the southern hemisphere where natural disasters seem more common and costly. Even in the US, funding is so limited that course development is agonizingly slow.

We tend to match complicated technical systems --high-risk and safety critical -- with complicated governing structures. Every disaster produces a cautionary reaction. We get a new and required "training" program, new guidelines and restrictions. While we need

these redundant systems and rules and safety devices, we can have too much faith in them. More pedestrians who use crosswalks die than jaywalkers. It is said they have a false sense of security and are less likely to look both ways.

It is also human nature to spread good news and hide the bad: the Good News Bias. Krepinevich writes of deadly stories—scary scenarios based on dirty bombs, pandemics, invasion threats and terrorist takeovers. He tells cautionary tales of failure to accept bad news, failure to tell the real truth in virtual events.

For example in 1932 in Hawaii, the Army and Navy performed a war exercise. On a Sunday morning, Admiral Yarnell launched planes from two new aircraft carriers dropping simulated bombs, sacks of flour, on Hickham Field and Pearl Harbor. The Army cried foul because they did this on Sunday when no one expected it. The umpire sided with the Army. No mention of the Navy's successful attack on Army assets appeared in the official report. Nor was it mentioned later when Japan bombed Pearl Harbor and Hickham Field on a peaceful Sunday morning in December 1942.

In 2002, an expensive military exercise involved retired Marine LT. General Van Riper who played the Red team commander of an insurgent army whom he realized were inferior to the US forces. His tactics were, in the words of the *Survivor* television show to “outwit, outplay and out last.” And he almost did. He used messengers instead of radio, assessed the Blue team's missile defenses, and sent out small boats to mingle with the US warships in the Gulf. With a few aircraft in support, his Red Team flotilla of small boats attacked with cruise missiles overwhelming the Blue Team's anti-missile detection capability and damaged or sank 16 warships. The next day, those in charge stopped the exercise, resurrected the fleet and constrained the Red team commander.

Today as ever, we tend to ignore the desert. Few of us want to think about intransigent enemy arguments, anti-satellite capability, information warfare, displaced and impoverished populations, even a global shipping industry that is too big to protect and too big to fail.

In a crisis, many countries and organizations do call on the simulation industry for models to clarify what might and has happened, provide simulation of evacuation routes or define rebuilding needs. Over time, and as budgets suffer, such planning and training seldom remains at the top of any list. Memories soon fade and other priorities intervene. In many countries there is rarely an opportunity to plan ahead when all available resources are insufficient to feed and shelter its citizens today. It is never easy to maintain enthusiasm for funding infrastructure of systems or bridges or cities or education or exploration or emergencies.

Managing the disaster: reducing risk, responding and recovery does present opportunities for simulation: supply chains for relief, training for first responders, games to help children cope and designs for rebuilding.

As an industry we don't seem to pick up on such opportunities and maybe this hampers the ability of others to see us, seriously as an industry. This year in the US, we were disheartened by the denial of our bid to have simulation accepted as a North American Industry Code (NAIC) classification—for the second time in 10 years. The reason cited was that we are not an industry. Appeals are in work. We do match the dictionary definition of a recognized aggregate of businesses producing a product named for the industry. We have, however, as Bill Waite, often reminds us in SimSummit not

developed our markets—which of course are everywhere because the applications of modeling and simulation are endless.

It may be that we are seen simply as competing entities with no real center. Maybe some see us as being like Gertrude Stein's Oakland, California with "no there there." Some see us as producing stuff for the military, space and some others. Some see a connection with games. But our real purposes are probably not generally evident.

We produce increasing accurate and understandable information—as multisensory as possible—creating shared mental models leading to better decision-making and action. This translates to jobs, a stronger economy and improved quality of life. That is what we are about.

Disasters –natural and man-made cost in the quadrillions every year. They harm and destroy jobs, the economy and quality of life. Disaster, environmental and risk management all involve time, money and lives. There is money to be made if only we figured it out. But it is not obvious.

In May, Antonio Cimino, from the University of Calabria, studied and reported on national and international opportunities for me at KSC. He included a search for modeling and simulation applied to crises and risky enterprises. An email request produced a few ideas, his interviews a few more, but the surface is scarcely scratched. We included these findings "To Extend Humanity's Reach in Space", the NASA/Calabria report on International and National Research Opportunities. It includes a section on International Cooperation in Crises and Risky Enterprises. The report is available at http://www.msc-les.org/IfLCD/IfLCD_report.pdf

Among the examples: At PEO-STRI and IST in Orlando they developed card games for training and one of them teaches some basic first aid like stopping a hemorrhage or clearing an obstructed airway. Players select treatment, apply sequential steps and cooperate with teammates. In another card game, people work on a team project coping with a lot of interruption as in real life. It is clear that game frameworks can be adapted to new audiences and unique situations such as disasters.

Virtually everyone knows something about supply chains. We plan grocery shopping and trips to the post office, drycleaners and pharmacy to be as efficient as possible. Maybe, like United Parcel Service, we plan our errands realizing that, in the US, routes with right turns are more efficient, use less time and fuel than left hand turns. Modeling and simulation could pose such puzzles so that kids and their families learn about supply chains during an emergency and, thus, have more realistic expectations of what is happening around them.

Research indicates that children suffer emotionally from disaster and often the grown-up are too busy to notice. What if there was a card game to teach kids what to do in a disaster? Maybe, also, available on computers, it could be watched in a village in India by a family in California or school in Ottawa. It could be an inexpensive card game distributed by relief workers. Vince Amico said that during World War II, the Navy developed a job aid, a card to teach sailors Morse code. It cost a penny, and it worked.

Jose Lagares who works for ASRC said that modeling and simulation helped identify a potential problem in Puerto Rico with an electric power plant serving a significant part of the Puerto Rican population. Simulation could predict the impact of a potential disaster since the plant was located very close to the ocean. Simulation could also support

continuity plans to ensure running of critical systems for the island's basic infrastructure and services

Francesca Olivo recalled that risk management of dangerous freight could be difficult especially over long distances and in remote areas. Research at the University of Genoa suggested a method for gathering even fragmentary data joining a Geographical Information System with a Monte Carlo simulator to evaluate danger along a route and estimate potential effects of an accident or sabotage

A researcher, Pau Fonseca I Casas, in Catalonia has been working with a research group there on simulation of hazardous natural situations—wildfire, avalanches, tsunamis and black tides.

David Miranda at KSC suggested that Discrete Event Simulation could model the entire emergency supply chain determining, for example, if the existing assets could handle the areas needs in a disaster or what might happen if one disaster piled on another. It could model “what if” scenarios rapidly to develop the best means for working with warehouses, transporters and operators. This could be especially useful should the disaster spread. Such simulation supports identification of what would work best and reduces “learning on the job” while things get worse.

Traditional problem solving states that identifying the problem is halfway to solving it. This is not the experience of those facing catastrophic situations. They encounter problems that cannot be definitively described, defined or solved--problems that are essentially unique and, always, consequential. Every effort to solve them has cost, impact, and, often, penalty.

Rittel and Webber state that such attributes describe planning problems which “are

inherently ‘wicked’.” They were talking about social policy but the idea resonates with our experience and that of risk reduction professionals everywhere as emergencies escalate.

Solving one “wicked” problem may create new, different and more difficult problems. Marginal short-term improvement can make needed structural change more difficult and more expensive. The term “unintended consequences” is now part of our vocabulary. Apparent similarities among “wicked” problems can be deceiving and potentially dangerous. One flood may not be like another. Direct transfer of any past solutions might prove useless and even harmful.

Our worldviews, knowledge, skills, experience, biases, geography, and health determine how we address these problems. Even how we feel on a given day--frame the variables we consider and can obscure experiences and ideas that might alter findings and make us change our minds about how best to plan for or deal with disasters when we face them. No one can do it alone. Being open to the knowledge and insights of others is necessary to avoid either narrowness or “group think.” When faced with overwhelming situations, we muddle through. But nowhere do we have a guarantee. “Improvement” as a best solution is a difficult idea to accept, but it may be the best we can do we can do if we focus only on managing the disaster—that is reducing, responding and recovering from it.

Act 3: Resolution

What can we do?

We can create a new model to provide decision makers with accurate, accessible information—as multisensory as possible—so they can form and communicate a shared

mental model that leads to right action that will save time, money, environment, equipment, limbs and lives. To paraphrase the Torah—if not us, if not now, when?

Some people have asked me about the difference between a plenary speech and a keynote. Admittedly there is a lot of smudging around the edges and they are closely related. But this is why you have an English major on the payroll. A plenary speaker, such as Joachim Fuchs, is an inside expert whose focus is on issues or a particular aspect important to our industry sector. A keynote speech refers to a principal underlying theme, maybe a reason or purpose behind a meeting. Here and now, it is the question of how best modeling and simulation might address the way we deal with crisis.

Although I have modeling and simulation in my DNA, I am not an insider in this industry. In 1993 when I became Technology Reinvestment Manager (TRP)—I did not even know the simulation industry existed anywhere, much less as a center of mass 40 miles away in Orlando I had been doing training, job and career and executive development, just within NASA, for over 10 years. I was not alone in my ignorance. In fact, the industry was described then as “stealth.” This was not so much because it was secret but because it was virtually invisible. When with Army, Navy and UCF simulationists and 4 simulation companies in Orlando, we shortly thereafter developed a TRP to form a consortium to make modeling and simulation technology more accessible. We were surprised when the State of Florida would not endorse it because they were as ignorant as I had been. Within a year or so-- we had changed things around—entered our proposal as a “maverick”, been funded with the money flowing through NASA and I was its project manager. We formed what is now the National Center for Simulation and

developed cheerleaders in Tallahassee and elsewhere. But even, today, a lot of the public does not know what the modeling and simulation community does.

What do we do? Our work saves lives. We help people save time and money. We do stuff that protects the environment and health, adds to their learning and enjoyment. Not bad way to make a living.

We know and do things that could help people not only manage disaster better but also do a better job of leadership when there is a disaster.

That matters. Disasters are a growth industry. Managing disaster—taking action to reduce risk, respond and recover—is good and absolutely necessary, but it is not enough.

Above all we must exhibit and teach the leaders how to think ahead and act smartly in the moment because scarcely anyone is doing it well.

Modeling and simulation can and must be part of the solution. We all need resilient people, land, economy and governance. We all want less risk, fewer consequential errors and more affordability. We need to help one another develop skills and confidence --the courage to work together for improvement.

The telling images on television are, indeed, of deer caught in the headlights. “The plan was not to have a spill.” We seem to be in the thrall of risk creep, false security, groupthink, the good news bias and lack of imagination. It is true a chief executive officer is required to think constantly about the stockholders. It is true the news gets blander as it rises. But that is not good enough.

Our attention has been on managing disaster—forecasting it, preventing it, planning for it, handling it as best we can when it happens and mopping up after. While we must continue and do more work in managing risk and disaster, clearly that is not good

enough. We could, should and might add the experience of our community to make managing disasters more effective. One current program announces that it gives disaster managers a background to understand the context of a disaster. We can do better than that.

Currently most emergency training addresses doctors, nurses, engineers, the military, social scientists, logistics personnel, risk managers and, last on the list, decision makers.

I would turn the list upside down.

What if put actual decision makers to the top of the list for emergency management training with a focus on leadership?

Leaders—either naturally or by design—must provide the big picture—the story—of what is expected and who needs to do what and when.

Simulation is perfect for that. Simulation provides increasingly accurate and understandable information that creates shared mental models supporting better decisions and action.

What if we used surprise, the essence of simulation, to help us all minimize the risk of being surprised in a catastrophe?

What if we took uncertainty seriously—identify risk and employ scenarios to narrow the range of uncertainty?

What if we figured how simulation could enable people to be experts—including experts at addressing disaster? We can examine the essence of expertise, as Gary Klein has done and continues to do. Building on some of his ideas--think about something at which you are an expert—not only at work—maybe fishing, cooking, painting water colors, washing your car, running a Marathon or race car driving or watching football. You may be an

expert at calculus, Light wave, Italian renaissance literature, and Canadian politics or rocket science. I am an expert on organizing a kitchen --a skill that does not, alas spill over to an office where I am abysmal. I know exactly where a thousand things are in my kitchen but once something is out of sight on my desk --it is lost. I live in terror that I will lose the last copy of something I write, but I can lay my hands instantly on a kitchen tool or ingredient. I can also read a play and, using mental simulation, see it simultaneously on stage. I can do the same thing with a film or project. The final product is nothing like that first mental simulation but it grows and changes as others add their ideas, new information resources surface or circumstances suggest or demand a different direction. For a long time, I thought everyone did this

At some point you and I were novice scholars or designers or simulationists (a word my spell check hates to accept) or whatever and at some point you became an expert. That tells us that people—maybe not all of them but many more—could be better at handling crises. The simulation community could help and that this could be a very worthwhile thing to do.

The literature suggests 3 possibilities: 1. People can learn to be better at making decisions, 2. Some people can learn to be better at making decisions and 3. No, people can never learn to make better decisions because their biases and prejudices and other failings will get in the way. Since I am an optimist and the vote is 2 to 1; I will stick to the idea that simulation, especially, can improve the odds. However, I also realize that Murphy was an optimist and things will go wrong. Jimmy the Greek said life is “8 to 5 against” so we cannot afford to relax our vigilance.

Klein and Madewell and others suggest elements that, I believe, simulation can address for helping leaders deal with the life cycle of a crisis. Some are obvious, others less so and some are mysteries that need a lot of research

They include seeing the big picture and its details, recognizing patterns and anomalies as well as integrating those patterns. The connection with simulation is obvious to us. Klein achieved notice with his studies of fire commanders on 9/11 who-- instead of using analysis and weighted options as he expected-- made instantaneous decisions using metaphor based on experience, mental simulation that looked forward and story that pulled it all together.

The big picture story of any disaster is always in motion-- a shifting condition --where we are all playing Chinese baseball. Chinese baseball according to R.J.H.Sui is a virtual game, a game like American baseball with one and only one difference--while the ball is in the air, anyone can move any of the bases. This, of course, like addressing a crisis, makes it a very difficult game to play. Goal setting is essential for disaster planning but we must internalize Eisenhower's admonition that plan are worthless while planning is essential.

We expect leader to be experts, of course, and this is especially true in a crisis like a landslide burying a hundred houses and an unknown number of people but the quality of those decisions involves more expertise than anyone person --a fire fighter, county commissioner or governor or community group possesses. We need other viewpoints anyhow because people in the same field begin to think alike, whether they are in oversight roles or not. Using simulation, we could prepare leaders to not only know the story but also provide good stories in emergencies.

My favorite story for executive leadership in a crisis and a wonderful opportunity for simulation is one in which the leader takes responsibility -- even if undeserved -- for what went wrong. They, therefore, demonstrate courage and honesty. Such a story shows the way out of a bad situation and is based on strongly held values such as truth. "The buck stops here. I take full responsibility." This is leadership. As a topic for an executive development simulation, it would prepare people for the "downs" as well as the "ups" of leadership. It is easy to imagine writing the "Oscar" success speech-- how valuable it would be to have practiced and be able to deal effectively and gracefully with really bad news.

We love to see ourselves as pattern detectors, noticing typicality, but we, too, need to look for the atypical, the things that did not happen. Simulation can enable disaster masters to be like Sherlock Holmes who picked up on the dog that did not bark. In Kepner-Tregoe problem solving the most interesting question is "Where do you not have this problem where you might expect it?"

You do not have a problem when things are normal. What this question does is establish normality as a baseline by which you notice that suddenly the birds have flown away and the sky has turned a weird shade of yellow. With a sense of the what and why, we can keep an eye on the main event, integrating the elements while noticing not only typical patterns but responding to things that are out-of-the ordinary.

In disaster as in any unexpected event, where the old rules do not apply, ability to improvise effectively is really important. This has a special connection with modeling and simulation. It is about identifying and being open to and accepting of the situation. In improvisational theater, there is only one rule. The participants must accept whatever

another participant says or does. They must act on the immediate situation. Acting does have lessons for our industry in terms of seeing through the eyes of others, rehearsing and absorbing feedback on how to do things or act in any situation. Meryl Streep, the American actress, spoke recently of a change she has experienced lately that she finds optimistic and speaks to a hopeful interest in seeing through the eyes of others. She said that although many men over the years have told her they admired her in an early film where she played a sweet but hapless girl, that lately men have told her they really identified with Miranda Priestly, the tough editor of Runway magazine in the *Devil Wore Prada*. They identify with her drive, work standards, toughness and loneliness at the top. It has been rare, Streep said, for heterosexual American males to identify with a female character although, in our culture, women identify with Hamlet, Huck Finn and Peter Pan. This shift matters because inability to identify with people who are somehow "different" hampers our efforts to really work in partnership or truly cooperate. Simulation can also allow us to try out the role of jihadist or cartel chief or, just those whose ethnicity, race or culture. Is unknown to us. Klein speaks; too, of seeing in your mind's eye what is on the other side of the hill. Experts do this based on experience but with simulation -- a virtual camera, perhaps, or augmented reality--we could shorten the process, show people what is out there and have them act on it.

Klein' sees "discrimination of detail" as of great importance in decision-making. It has to do with how different minds work and we know precious little about that. Klein thinks ability to pick up on detail is probably of great importance but neither he not anyone else has a handle on how to isolate that. My son who is now a

composer and professor of composition, could, when he was 10, translate his musical ideas to notes on paper that musicians could play and my husband has never forgotten any beautiful sailboat he has ever seen. Artists do it. Scientists and inventors do it. If we understood this better—we might be able to do some critical things a lot better. This could be a good area for research because it may be a major key to understanding why some people can react quickly and well in a crisis and others do not.

On Klein's list --as it should be on all our lists--- is "knowing our own limitations." His research suggests that metacognition—thinking about thinking—promotes ability to change tactics, focus on the expertise of others and, even, interdependence. Again a clear topic for simulation.

The Apollo 1 fire, Challenger, Columbia and Katrina and now Ocean brought charges of "Lack of imagination." It is a difficult charge to answer. As "second-guessers", we easily see the poor decisions and ineffective actions that plagued these events. Synthesizing and integrating imagination systematically into our work --and thus our success--remains however, a challenge. What is the opposite of failure of imagination or "crisis in imagination" as A.C. Clarke called it? A plenty of imagination? Perhaps the clue lies in something else that Meryl Streep said, "Pretending is imagined possibilities." Klein tells of a scenario developer and trainer who closed the door and said softly, that a good fire commander, a model of leadership in a crisis, needed a "rich fantasy life." Presumably, he felt he could not let his colleagues know. That is too bad.

"Pretending or acting is", as Streep also said, "an important life skill." Actors act. They interact. We do that in simulation. It has its basis in Newtonian physics. Every action has

a reaction and that is what matters. The actor, the leader, must react in a nanosecond to a glance or a word. It can mean all the difference in what happens next. This underscores that it is what the listener does that matters, not what the speaker says. It matters what people do

What if we recognized that the hard sciences of simulation need the difficult sciences of human behavior, cultural challenges and communication so that, together, we can test ethical and technical issues? Although Our Western culture seems hostage to ancient pre-scientific thought that continue to value one discipline over another and can hamper innovation; we are beginning to see that that hampers innovation. Expanded external knowledge sharing is critical to performance improvement of large complex enterprises and systems. The analyst must use intuition while the humanist seeking to influence cannot be effective without attention to logic, information and analysis. What if we truly recognized that we need discussions among many disciplines that could be part of the solution?

I will repeat something that some of you have heard me say before—simulation, like space exploration, is too important to be left solely to the scientists and engineers. Its very complexity requires a transdisciplinary approach. Not, as Christopher Stapleton, explained a multi-disciplinary approach because then all you get then are people from many disciplines talking to themselves.

Transdisciplinary may be a hard concept to accept, but 10 years ago, the importance of the story in simulation was a new idea. Not now.

With our experience in Space -- a hostile environment, daunting distances, dangerous multi-decadal work of massive complexity with highly dispersed teams -- comes the

awareness, the good news, that with simulation we see things from a new, previously unimagined perspective. Simulation surprises us. In fact, surprise is its essence. We understand concepts that had eluded us and grasp how to do work that seemed impossible.

A departed former colleague once remarked that the simulator had been the unsung hero of Apollo 13. It is true. NASA engineers on the ground used their experience, and more importantly, reflection and their simulation research to prevent disaster. NASA had to abort the plan for Apollo 13 to be the third mission to land on the Moon when an explosion in an oxygen tank crippled the spacecraft. The situation was grim. Needing to devise a safe return using the lunar module, as a “life raft”—despite limited power, heat or potable water—was no simple answer. Using simulation, NASA engineers called on everything they knew to both enable the astronauts to orbit the Moon in a slingshot maneuver and also take advantage of what power could be coaxed out of the ailing spacecraft in order to bring them home. The task was compounded by a complicated series of switch throws and circuit breaker pulls that had proven to be too time consuming in an Apollo 10 training simulation that left the “virtual crew dead”. It was imagining the possibilities, reflection and research following that undesirable event that resulted in a new activation list cutting procedures to a feasible minimum. NASA used the new procedure although it was not yet certified, and it did its job.

The simulation technology that helped save the crew is scarcely remembered. It proved to be unobtrusive and undemanding of attention. That is an appropriate use of appropriate technology setting the standard for simulation that supports leadership development and international cooperation supporting risky enterprises and, especially crises.

Modeling and simulation has such great potential but its course of direction and maturity, as an industry, is unclear. It is good that we all support education and workforce development. It is good that we share knowledge and I just think we can do more for the Greater Good. We could use our expertise to minimize the risk of being surprised when we have ignored bad news and failed to address uncertainty and pending catastrophe. We have the power and the obligation to enable people to take part in a dangerous world. I realize that such effort is not easy. I know that no good deed goes unpunished. Nonetheless, we could if we want to, change the world. We could-- starting here, starting now.